CLAIMS

What is claimed is:

1. A functionally-graded metal substrate comprising:
a functional insert;
a surrounding body;
wherein the functional insert and the surrounding body are two metal compositions in the x-y plane of the substrate; and,
wherein the surrounding body surrounds the functional insert.

2. The functionally-graded metal substrate of claim 1 wherein the surrounding body surrounds the functional insert in at least two dimensions.

3. The functionally-graded metal substrate of claim 1 wherein the functional insert extends from a top surface of the functionally-graded metal substrate to the bottom surface of the substrate.

4. The functionally-graded metal substrate of claim 1 wherein the functional insert extends from one surface of the substrate to an internal location of the substrate.

5. The functionally-graded metal substrate of claim 1 having a density of at least about 90% of theoretical.

6. The functionally-graded metal substrate of claim 1 wherein the functional insert comprises a metal composition selected from the group consisting of copper, nickel, iron, beryllium, aluminum, silver, copper-beryllium, copper-zinc (bronze), copper-tin (brass), 64% iron/36% nickel (Invar™) ~~and~~, 54% iron/29% nickel/17% cobalt (Kovar™), copper-iron, nickel-niobium, nickel-silver, nickel-copper, iron-copper,

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iron-copper-carbon, iron-copper-nickel, iron-chromium, iron-copper-tin, copper-nickel-titanium-aluminum, nickel-copper-titanium, copper/tungsten, copper/molybdenum, aluminum/silicon carbide, aluminum/aluminum nitride, copper/aluminum, silver/Invar™, copper/cubic boron nitride, copper/diamond and copper/high conductivity carbon fiber and combinations thereof.

7. The functionally-graded metal substrate of claim 1 wherein the surrounding body comprises a metal composition selected from the group consisting of copper, nickel, iron, beryllium, aluminum, silver, copper-beryllium, copper-zinc (bronze), copper-tin (brass), 64% iron/36% nickel (Invar™) ~~and~~ 54% iron/29% nickel/17% cobalt (Kovar™), copper-iron, nickel-niobium, nickel-silver, nickel-copper, iron-copper, iron-copper-carbon, iron-copper-nickel, iron-chromium, iron-copper-tin, copper-nickel-titanium-aluminum, nickel-copper-titanium, copper/tungsten, copper/molybdenum, aluminum/silicon carbide, aluminum/aluminum nitride, copper/aluminum, silver/Invar™, copper/cubic boron nitride, copper/diamond and copper/high conductivity carbon fiber and combinations there of

8. The functionally-graded metal substrate of claim 1 wherein the surrounding body is a copper/tungsten MMC containing from about 5% to about 50% by weight copper, and wherein the functional insert is a copper/tungsten MMC containing from about 20% to about 80% copper.

9. The functionally-graded metal substrate of claim 1 wherein the surrounding body is a copper/tungsten MMC containing from about 5% to about 40% by weight copper, and wherein the functional insert is a copper/tungsten MMC containing from about 30% to about 50% copper.

10. The functionally-graded metal substrate of claim 1 wherein the surrounding body is a copper/tungsten MMC containing from about 10% to about 30% by weight copper, and wherein the functional insert is a copper/tungsten MMC containing from about 30% to about 45% copper.

11. The functionally-graded metal substrate of claim 1 wherein both the surrounding body and the functional insert comprise copper/tungsten or copper/molybdenum, and wherein the concentration of copper in the functional insert is greater than the concentration of copper in the surrounding body.

12. The functionally-graded metal substrate of claim 1 further comprising:

a heat-generating component attached thereon.

13. The functionally-graded metal substrate of claim 12 wherein the heat-generating component is attached to the functional insert and wherein the heat-generating component is a chip.

14. The functionally-graded metal substrate of claim 1 wherein the functional insert has a thermal conductivity that ranges from about 200 W/mK to about 400 W/mK and wherein the surrounding body has a CTE that ranges from about 5.6 ppm/°C to about 7.0 ppm/°C.

15. A functionally-graded metal substrate comprising:

a functional insert;

a surrounding body;

wherein the functional insert and the surrounding body are two metal compositions in the x-y plane of the substrate;

wherein the surrounding body surrounds the functional insert in at least two dimensions;

wherein the functional insert extends from a top surface of the functionally-graded metal substrate to the bottom surface of the substrate;

wherein the functional insert and the surrounding body comprise a metal composition selected from the group consisting of copper, nickel, iron, beryllium, aluminum, silver, copper-beryllium, copper-zinc (bronze), copper-tin (brass), 64% iron/36% nickel (Invar™) and 54% iron/29% nickel/17% cobalt (Kovar™), copper-iron, nickel-niobium, nickel-silver, nickel-copper, iron-copper, iron-copper-carbon, iron-copper-nickel, iron-chromium, iron-copper-tin, copper-nickel-titanium-aluminum, nickel-copper-titanium, copper/tungsten, copper/molybdenum, aluminum/silicon carbide, aluminum/aluminum nitride, copper/aluminum, silver/Invar™, copper/cubic boron nitride, copper/diamond and copper/high conductivity carbon fiber; and,

wherein the functionally-graded metal substrate has a density of at least about 90% of theoretical.

16. A functionally-graded metal substrate comprising:

a functional insert;

a surrounding body;

wherein the functional insert and the surrounding body are two metal compositions in the x-y plane of the substrate;

wherein the surrounding body surrounds the functional insert in at least two dimensions;

wherein the functional insert extends from a top surface of the functionally-graded metal substrate to the bottom surface of the substrate;

wherein the surrounding body is a copper/tungsten MMC containing from about 5% to about 50% by weight copper, and wherein the functional insert is a copper/tungsten MMC

containing from about 20% to about 80% copper; and,

wherein the functional insert has a thermal conductivity that ranges from about 200 W/mK to about 400 W/mK and wherein the surrounding body has a CTE that ranges from about 5.6 ppm/°C to about 7.0 ppm/°C.

17. The functionally-graded metal substrate of Claim 16 further comprising:

A heat-generating component attached thereon.

18. A process for making a functionally-graded metal substrate, the process comprising:

filling the cavity of a metal body with a functional insert powder composition; and,

sintering the functional insert powder composition.

19. The process of claim 18 wherein the metal body is comprised of a metal composition selected from the group consisting of copper, copper oxide, nickel, iron, beryllium, aluminum, silver, copper-beryllium, copper-zinc (bronze), copper-tin (brass), 64% iron/36% nickel (Invar™) and 54% iron/29% nickel/17% cobalt (Kovar™), copper-iron, nickel-niobium, nickel-silver, nickel-copper, iron-copper, iron-copper-carbon, iron-copper-nickel, iron-chromium, iron-copper-tin, copper-nickel-titanium-aluminum, nickel-copper-titanium, copper/tungsten, copper/molybdenum, aluminum/silicon carbide, aluminum/aluminum nitride, copper/aluminum, silver/Invar™, copper/cubic boron nitride, copper/diamond and copper/high conductivity carbon fiber

20. The process of claim 18 wherein the functional insert powder composition is comprised of a metal composition selected from the group consisting of copper, nickel, iron, beryllium, aluminum, silver, copper-beryllium, copper-zinc

(bronze), copper-tin (brass), 64% iron/36% nickel (Invar™) and 54% iron/29% nickel/17% cobalt (Kovar™), copper-iron, nickel-niobium, nickel-silver, nickel-copper, iron-copper, iron-copper-carbon, iron-copper-nickel, iron-chromium, iron-copper-tin, copper-nickel-titanium-aluminum, nickel-copper-titanium, copper/tungsten, copper/molybdenum, aluminum/silicon carbide, aluminum/aluminum nitride, copper/aluminum, silver/Invar™, copper/cubic boron nitride, copper/diamond and copper/high conductivity carbon fiber.

a 21. The process of claim ~~19~~ 18 wherein the metal body is solid metal.

a 22. The process of claim ~~22~~ 18 wherein the functional insert powder composition is a loose powder.

a 23. The process of claim ~~23~~ 18 wherein the sintered functional insert is infiltrated with a molten metal compound.

a 24. The process of claim ~~19~~ 18 wherein the metal body is a compact of a surrounding body powder composition and the surrounding body powder composition is compacted prior to sintering; and

wherein the surrounding body powder composition and the functional insert powder composition are sintered simultaneously.

a 25. The process of claim ~~25~~ 24 further comprising:

infiltrating the sintered functional insert composition or the sintered surrounding body composition or both with a molten metal compound.

a 26. The process of claim ~~19~~ 18 wherein the metal body is a compact of a surrounding body powder composition and the

surrounding body powder composition is compacted prior to sintering;

wherein the functional insert powder composition is compacted prior to sintering; and,

wherein the surrounding body powder composition and the functional insert powder composition are sintered simultaneously.

a 27. The process of claim ~~27~~ 26 further comprising:

infiltrating the sintered surrounding body or the a sintered functional insert or both. with a molten metal compound

a 28. The process of claim ~~26~~ 27 wherein the process produces a functionally-graded metal substrate that has a least two discrete portions, a functional insert and a surrounding body, in the x-y plane, and wherein the surrounding body surrounds the functional insert.

a 29. The process of claim ~~29~~ 28 wherein the surrounding body powder composition contains copper/tungsten powder; and

wherein copper is present in the amount from about of 5% to about 50% by weight; and

wherein the functional insert powder composition comprises copper/tungsten powder containing from about 20% to about 80% by weight copper.

a ~~30~~. 30 The process of claim ~~30~~ 29 wherein the molten metal compound is copper.

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31. The process of claim 26 ~~wherein~~ the sintering temperature is ~~about~~ equal to or greater than the melting temperature or the eutectic temperature of at least one ~~metal~~ composition.

32. A process for making a functionally-graded metal substrate comprises:

compacting a surrounding body powder composition having a cavity therein;

placing a functional insert powder composition into the compact of the surrounding body composition;

sintering the compact containing functional insert powder composition and the compact containing the surrounding body powder composition simultaneously; and,

infiltrating the sintered functional insert or the sintered surrounding body or both with a molten metal to form a metal substrate that has a functional insert and a surrounding body that surrounds the functional insert.

a 33. The process of claim ~~33~~ 32 wherein the molten metal is a metal that melts at about 1400 deg. C or less.

a 34. The process of claim ~~34~~ 33 wherein the surrounding body surrounds the functional insert in at least two dimensions; and,

wherein both the surrounding body and the functional insert comprise copper/tungsten or copper/molybdenum, and wherein the concentration of copper in the functional insert is greater than the concentration of copper in the surrounding body.

a 35. The process of claim ~~35~~ 34 wherein the functional insert extends from a top surface of the functionally-graded metal substrate to the bottom surface of the substrate; and

wherein a heat-generating component is attached to the functional insert.

a a 36. ~~The~~ a process for making a functionally-graded metal substrate ~~comprises~~ comprising.

compacting a surrounding body powder composition having a cavity therein;

compacting a functional insert powder composition to form a compact;

placing the compact of the functional insert powder composition into the compact of the surrounding body composition; and,

sintering the compact containing functional insert powder composition and the compact containing the surrounding body powder composition simultaneously.

a 37. ~~The~~ process for making a functionally-graded metal substrate, the process comprising:

placing a solid functional insert in the cavity of a solid metal body; and,

bonding the metal body and the functional insert to form a metal substrate having a functional insert and surrounding body in the x-y plane.

a 38. The process of claim ~~38~~ 37 wherein bonding is achieved via brazing or pressure-assisted or pressureless diffusion bonding.

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